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Comparing the accuracy of POC vers. Lab. (Capillary, Venous and arte-rial) blood glucose level in severely shocked verse non-shocked critically Ill patients

Abstract

Background: Glucose monitoring among critically-ill patients has been a topic of attention for long time to prevent both hyperglycemia and hypoglycemia, which is important in an intensive care unit. Use of point of care blood glu-cose meters within some critically ill patient populations has resulted in varying degrees of confusion about off-label use and potential discrepancies in results. The aim of this study was to compare the accuracy of point of care capil-lary and venous/arterial samples verse venous/arterial samples by laboratory testing in critically ill both shocked and non-shocked patients.

Methodology: This is prospective case control study that was conducted among 268 critical ill patients among whom, capillary, Venous and arterial Blood Sample during routine care which is requested by treating physician will be done by the same bedside nurse. The study was conducted in King Fahd Miliary Medical Complex Dhahran Saudi Arabia.

Results: In this study, we were able to collect data for 268 patients. The results showed no significant difference between POCT and lap results of both of venous and central blood (P=0.389 and 0.208) where POCT showed slight-ly higher results with venous glucose concentration of 10.18 and 10.05 (POCT and lab tests respectively) and 9.18 and 9.54 in POCT and lab tests respectively. Moreover, the mean difference between POC and lab analysis of ve-nous, arterial and central glucose were 1.03, -1.8 and 0.7 mmol.

Conclusion: We did not find a significant difference between results of POCT and regular laboratory analysis of glucose concentrations in critically ill patients except for arterial blood glucose. Using of POCT is slightly accurate with no difference between shocked and non-shocked patients compared to lab blood analysis.

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Introduction

One of the most important aspects of the critical care is to maintain normoglycemia in patients with established diabetes or stress-induced hyperglycemia. Hyperglycemia has been found to have a significant detrimental effect in those patients.1,2 Appropriate management of hyperglycemia had been found to have a significant impact on re-ducing mortality and admission duration as well as preventing of acute renal injury and providing faster weaning from mechanical ventilation.1,3,4 Moreover, hypoglycemia has its associated side effects5 and has been found to be an independent predictor of mortality in several studies.6,7

Furthermore, several organizations have determined their own target blood glucose levels for ICU patients8,9 and to achieve these goals, many hospitals use point-of-care (POC) glucose meters in order to monitor glycemic status. The using of POC glucose meters provides the advantage of portability, ease of use as well as readily available results which is significantly important in those patients who required tight glycemic control where waiting for central la-boratory results make the rapid adjustments and management of glucose level in therapy impractical. Most of the used meters have found to be accurate in stable outpatients however, among critically ill patients, results showed that there are various confounding factors that could interfere with POC glucometer as for example, hematocrit, oxygenation, acid-base disturbance, temperature and shock states.10,11

Considering presence of shock, several mechanisms had been discussed as possible explanations for its impact on accuracy of POC glucometers including that peripheral vasoconstriction in hypoperfusion states which could lead to increased the glucose extraction by tissues because of low capillary flow resulting in falsely underestimate of glu-cose measurement with capillary blood.12,13 Several publications concerning measuring blood glucose level in criti-cally ill patients showing acceptance variation with point of care results compared to laboratory results however they didn't differentiate between shocked relative to non-shocked patient [4,5]. Previous studies that had been con-ducted among critically ill patients included only small number of measurements taken for patients in shock that resulted in a heterogeneous cohort.1,14–19 Therefore, in this study, we aimed to compare the accuracy of point of care capillary and venous/arterial samples verse venous/arterial samples by laboratory testing in critically ill both shocked and non-shocked patients.

Methodology

This is a prospective case control study that was conducted among 268 critical ill patients who admitted to King Fahd Miliary Medical Complex Dhahran Saudi Arabia. Inclusion criteria included all adult, 18 years old and older, non-pregnant patients who admitted to the hospital with and without diabetes millitus after obtaining informed consent from primary decision makers. Exclusion criteria included hypovolemic shock because of severe active bleeding, patients with

bleeding disorders, the use of substance that could interfere with POC glucose meter technol-ogy including icodextrin-containing solutions, intravenous immunoglobulins, abatacept, maltose), and lack of consent. In this study, we collected data of patients and laboratory results at baseline from the chart review including demographic factors as age, gender and anthropometric measurements as well as historical data as chronic comor-bidities. Baseline clinical characteristics of patients included initial vital signs, the Glasgow Coma Scale score with derived verbal scores for intubated patients, the need for ventilator or dialysis and presence of acute significant ar-rhythmias. Laboratory parameters recorded were arterial blood gas analysis, serum creatinine, albumin, and com-plete blood count. The laboratory values taken at the time most proximate to the blood glucose determination were recorded.

Data was collected about the results of POC and lab analysis of blood for glucose concentrations, three blood sam-ples were taken from venous, arterial and central blood as well as capillary blood. Data about the results of POC and lab analysis were taken and used in our comparison. The tests were conducted after request by treating physi-cian and were done by the same bedside nurse. All data was entered, cleaned using MS Excel and anlayzed using SPSS version 26. Frequency and percent were used for descripting of the categorical variables while mean and standard deviation were used for descriping of ongoing of the variables. t paired test was used to analysis of the possible difference between measures of glucose using both of POC and lab analysis of blood. All statement with P value lower or equal to 0.05 is considered significant.

Results

In this study, we were able to collect data for 268 patients admitted in KING FAHD MILITARY MEDICAL COM-PLEX, DHAHRAN, Saudi Arabia. Among these patients, 26.1% were males with shock and 18.3% shocked fe-males. The mean age is 63.01 years old. Most of included shocked patients were in cardiology department (20%) and only 2.5% of the shocked patient were in the neuro-surgery department. Moreover, 23.5% of the shocked pa-tients were diabetic and 17.5 % needed hemodialysis while 59.3 % were ventilated (Table 1).

Table 1 Patients' general characteristics (N=268)

		Shocked	Non - shocked
Gender	Male	70 (26.1%)	97 (36.2%)
	Female	49 (18.3%)	52 (19.4%)
	Total	119 (44.4%)	149 (55.6%)
Age	Mean (SD)	63.01 (17.26)	
Specialty	Cardio	54 (20.1%)	27 (10.1%)
	Endocrine	2 (0.7%)	4 (1.5%)
	Neuro Surgery	7 (2.6%)	16 (5.9%)
	Pulmonology	6 (2.2%)	15 (5.6%)
	Other	9 (3.4%)	21 (7.8%)
D.M.2	Yes	63 (23.5%)	53 (19.8%)
	No	13 (4.9%)	10 (3.8%)
Hemodialysis	Yes	47 (17.5%)	28 (10.4%)
	No	51 (19.1%)	48 (17.9%)
Mechanical Venti	Yes	159 (59.3%)	50 (18.7%)
	No	9 (3.4%)	20 (7.5%)

Furthermore, 53.5 % of the patients had SR arrhythmia and 27.5 % had atrial fibrillation (AF) (Figure 1). Moreover, 78.5 % of the patients need insulin infusion during their admission. In addition, we found that 55.6 % of the pa-tients were non shocked patients while 44.4 % were shocked. In consideration of baseline characteristics of the pa-tients, all available data were presented in Table 2. The mean U. O in the last 24 hour was 2195.28 ml in the shocked patients as a mean of 2064.9 in the non-shocked patients group. The mean weight of patients was 74.9 Kg in the shocked patients group as the mean in the non-shocked is 77.3 Kg. The mean temperature of patients during their stay in hospital was 36.82 C with mean heart rate of 91.2 for the shocked patients group. The mean score of SOFA and APACHE 2 were 9.41 and 26.3 for the shocked patients respectively.

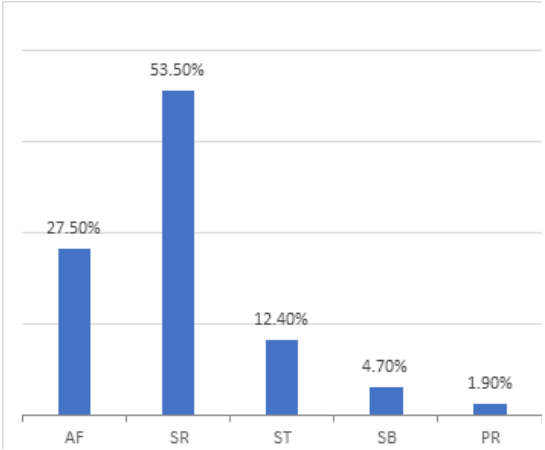

Figure 1 Type of arrhythmia.

In Table 3, we compared between the results of POC analysis and Lap analysis considering venous/arterial glucose values in patients who critically ill. The results showed no significant difference between POCT and lap results of both of venous and central blood (P=0.389 and 0.208) where POCT showed slightly higher results with venous glu-cose concentration of 10.18 and 10.05 (POCT and lab tests respectively) and 9.18 and 9.54 in POCT and lab tests respectively. The only difference between POCT and lap analysis of glucose concentrations was reported in arterial glucose concentrations where lap analysis showed significant higher glucose concentrations with 11.41 compared with 9.66 in POCT analysis (P=0.029) (Table 3). Moreover, the mean difference between POC and lab analysis of venous, arterial and central glucose were 1.03, -1.8 and 0.7 mmol.

Moreover, in Table 4, we showed the difference between results of POCT and Lab analysis of glucose concentra-tions in shocked and non-shocked patients. The results showed that there is no significant difference between the results of POCT or lab analysis between shocked and non-shocked patients with slightly difference between POCT and lab analysis. POCT showed that venous glucose concentration was higher in non-shocked patients and lower in case of capillary however, lab analysis showed that venous glucose concentration were higher in shocked patients and slightly lower in case of central analysis.

Discussion

The appropriate measurement of glucose level of patients is extremely important especially among patients who are on a tight glycemic protocol and at increased risk of hypoglycemic episodes. This is typically true in this study among our population since many of these patients are not able to communicate with either the physicians

or nurs-es and their signs of hypoglycemia are not readily available. POCT provides some advantages for using instead for regular blood glucose test including availability of glucose value to nurse within 2 minutes and it is immediately vis-ible in the hospital information system. Moreover, POCT devices need very small amount of blood and risk of spill-ing blood from the syringe, or the device is very low.20

Table 2 Baseline characteristics

	Shocked Mean	Shocked Standard Deviation	Non-shocked Mean	Non-shocked Standard Deviation
U. O (ml/h)	115.6	381.07	110.2	321.4
last 24hr (ml)	2195.28	1813.3	2064.9	1720.2
Wt (Kg)	74.9	17.8	77.3	18.1
GCS	20.1	191.9	18.3	181.1
MAB	76.7	17.1	75.1	18.7
Temp	36.82	2.91	36.91	3.1
H.R.	91.2	22.3	88.3	21.2
Capillary Refill	73.4	0.8	72.1	0.7
Serum Creatin	131.7	125.7	133.1	122.1
Albumin	44	176.2	41.7	171.3
Lactate	2.5	3.3	2.1	3.1
Hematocrit	29.1	20.9	28.2	20.3
Hemoglobin	9.2	1.7	9.4	1.8
WBC	13.7	6.1	12.4	5.9
PH	7.4	0.3	7.37	0.2
PO2	115.9	487.2	116.8	491.2
Lactate	1.82	2.31	1.72	2.2
BE	2.9	11.2	2.81	10.8
SOFA score	9.41	4.71	8.9	4.3
APACHE II score	26.3	21.9	25.9	22.1

Table 3 The difference between POCT and Lap results considering glucose concentration

	POC analysis		Lap analysis		P-value
	Mean	Standard Deviation	Mean	Standard Deviation	
Capillary	9.22	3.54	-------	-------	
Venous	10.18	5.13	10.05	5.34	0.389
Arterial	9.66	3.15	11.41	10.31	0.029*
Central	9.18	3.87	9.54	3.84	0.208

Table 4 The difference between POCT and Lab analysis in shocked and non-shocked patients

Condition of the patients		POC Venous	POC Capillary	Lab Venous	Lab Central
No shock	Mean	10.3525	9.6739	9.981	9.5455
	N	61	56	58	11
	Std. Deviation	4.71606	3.6638	4.39655	3.7652
Shock	Mean	9.6955	9.732	10.1829	9.6521
	N	22	107	17	21
	Std. Deviation	6.23809	4.1341	7.92549	3.97787
P-value		0.61	0.532	0.846	0.996

In order to apply glucose regulation protocol, it is a need for fast and accurate way to measure the blood glucose levels.21,22 Applying these protocols increase the nurse workload thus it should be feasible as well.12,13,23 Therefore, this means that not the most accurate device but the most feasible and having still fairly accurate glucose analyzed would be chosen for this process. On the other hand, in critical ill patients, hypoglycemia is critic, and its warning symptoms are absent, thus these devices should be very reliable in the low range too.14–19 When we compared the results between POCT results with lab analysis of glucose concentrations, we found that there is no difference be-tween the venous and central glucose while significant difference was found between arterial glucose concentra-tions. Moreover, we found that POCT overestimated the venous and central glucose concentration and underesti-mated the arterial glucose concentration. According to previous study conducted by Petersen J et al., showed that glucose meters overestimated blood glucose levels in arterial,

central, venous and capillary samples when compared to reference standard concentrations24 and these results also reported in study of Boyd et al.,25 and Critchell et al.19 In another study conducted by Clarke et al, the authors found a good accuracy for the subcutaneous CGMS in the euglycemic range26 and study of Goldberg et al, which found that POCT had pearson correlation coefficient of 0.88 with 98.7 % within the clinical acceptable zones.27 In a study conducted by Cook a et.al., the authors found that lab glucose values for blood in critical ill patients from catheter was significantly different from POC value for blood from the catheter (p=0.001) and from the fingerstick (p=0.001).14 Moreover, another study showed that clinical agreement between POCT and lab analysis is better in central than arterial blood analysis and in case of hypogly-cemia, clinical agreement was found only in 26.3 % of cases with capillary blood analysis.16

However, hypoperfusion that occurred during shock in patients is known to be a problem in the underestimation of glucose value with capillary sampling,19,21,22 it is not found to be a major issue in this study. For example, no signifi-cant difference considering glucose concentrations between shocked and non-shocked patients considering POCT or lab analysis. This results are similar to the results of previous studies.12,13,23 In this study, we depended on seriously ill patients because we aimed to test the reliability of POCT under specific conditions as shock. However, this causes low population availability for sample inclusion which lead to have little data points under extreme conditions of pH, temperature, electrolyte disturbances, and hypoglycemia to make statements about the reliability of specific analyzers under these circumstances.

Conclusion

In conclusion, in this study, we did not find a significant difference between results of POCT and regular laboratory analysis of glucose concentrations in critically ill patients except for arterial blood glucose. Using of POCT is slightly accurate with no difference between shocked and non-shocked patients compared to lab blood analysis.

Acknowledgments

None.

Conflicts of interest

None.

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